

My Virtual Colleague: A State-of-the-Art Analysis of Conversational Agents for the Workplace

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Abstract

Conversational interfaces at the workplace are not a new idea, but it is only the recent technological advancements that turned what was once a vision into near-future reality. Improved reliability and accuracy enable conversational systems to be used in higher stake environments, such as the workplace. In this work, we perform a literature review on concepts proposed to incorporate Conversational Agents (CA) into the workplace. We found 29 workplace CAs designed for workers that contribute to eight different application domains. Based on the studies of these CAs, we compiled a list of aspects to be considered when designing such CAs and identified starting points for further research.

1. Introduction

Science-fiction film makers once envisioned systems in future workplaces to be operated through natural language commands [1]. Although the fully conversational workplace was still a vision for the far future, the first conversational agents (CA) ELIZA [2] and Parry [3] were presented soon after. Today, over 50 years later, the film makers vision could become reality with the emergence of CAs in the form of Siri, Alexa or Google Assistant. However, common CAs like these are mostly used for low-stake purposes such as finding a navigation route or switching lights in a smart home. Despite their popularity in private environments, concepts for CAs at the workplace are just gaining attention in the recent years [4, 5].

As the development of CAs evolves rapidly, we aim to compile an up-to-date overview of workplace CAs (WCAs) that have been proposed in scholarly research which leads to our first research question:

RQ1: What are the state-of-the-art WCA concepts?

Based on our findings, our second research question targets the design of WCAs. Due to the novelty of this type of CA, we neither expect a large number of results

nor extensive studies, therefore we aim to extract general aspects rather than defined design principles:

RQ2: Which aspects need to be taken into consideration in the design of a WCA?

In order to answer these research questions, we perform a Systematic Literature Review (SLR) [6]. The remainder of this paper is structured as follows: In Section 2 we introduce the different types and dimensions of CAs. Then, we explain our SLR process in Section 3 and present our results in Section 4. Section 5 and Section 6 conclude this paper by discussing our findings, the limitations and starting points for further research.

2. Conversational Agents

CAs are software programs that are capable of “interpret[ing] and respond[ing] to statements made by users in ordinary natural language” [7] and should not be confused with the more general term of *bots* which are mostly non-conversational “automata used for background tasks” [8]. Common synonyms for CAs are *chatbots*, *conversational (artificial) intelligence* (with focus on technical aspects, e.g. [9]) or conversational (user) interface (with focus on user interaction, e.g. [10, 11]). Initially proposed by Alan Turing in 1950 [12], early CAs like *ELIZA* [2] and *Parry* [3] were presented in the 1960s and 70s, based on handcrafted rules to simulate human behavior. Although the early day CAs were perceived as convincing [13], the technological advancements in the last decade enabled CAs to become sufficiently intelligent to actually be useful [14].

There are many taxonomies proposed in scholarly research to differentiate and classify CAs. Table 1 summarizes several common dimensions: *Domain Breadth* and *Depth* are the total number of topics and the degree of detail supported by the CA. *Session Length* includes two values, the designated number of conversation turns per session (CPS) and whether the intent is to minimize or maximize the session length. *Emotionality* indicates whether a CA is capable of

Dimension	Example Values	Sources
Domain Breadth	General Purpose, Domain-Specific; Open, Closed	[17, 18]
Domain Depth	Shallow, Deep	[8]
Session Length	Number of CPS, Max/Min CPS	[8, 19]
Goal Direction	Goal-Oriented, Non-Goal-Orient.	[18]
Emotionality	Emotional, Non-emotional	[18]
Representation	Disembodied, Embodied	[18]
Modalities	Speech, Text, Multi-Modal	[17, 18]

Table 1. Dimensions of Conversational Agents

showing emotions including being empathetic and act accordingly. Lastly, the dimensions *Representation* and *Modalities* apply to the instantiation of the CA, that is, the amount of human characteristics (e.g. visualization as a human being, physical embodiment as a robot) and the input and output interfaces the CA uses to interact with the user, respectively.

CAs are often divided into three major categories (e.g. [8]): *Intelligent (Personal) Assistants* (IPAs), *Goal-/Task-Oriented CAs* (GCAs) and *Virtual Companions* (VCs). IPAs like *Siri*¹ and *Google Assistant*² can perform a large range of simple actions, most of which are completed with very few CPS with the goal to minimize this number. Same optimization goal is valid for GCAs, however, they only support a narrow range of functions that require a higher CPS by the nature of the task (e.g. placing an order). In contrast, VCs are designed to maximize CPS to maintain an interesting conversation for as long as possible. Common use cases for virtual companions are entertainment purposes (e.g. *Zo*³) and Cognitive Behavioral Therapy (e.g. *Woebot* [15], *Wysa* [16]).

3. Review Method

In this section, we describe the method used for our SLR in detail, following the plea for more rigor

¹<https://www.apple.com/siri>

²<https://assistant.google.com>

³<https://www.zo.ai>

in literature reviews [20]. To ensure replicability, we present our search process in detail.

We conducted exploratory searches in Google Scholar to retrieve established synonyms for our central terms “CA” and “workplace”. For CA, we selected “chatbot” and the combinations of “conversational” with “bot”, “agent”, “AI”, “UI”, “intelligence” and “interface”. For “workplace”, we used “workspace” and “workstation” as synonyms and excluded the term “work” due to its ambiguous meaning. Our final search query therefore was ((“conversational” (“agent” OR “UI” OR “AI” OR “interface” OR “intelligence” OR “bot”)) OR “chatbot”) AND (“workplace” OR “workspace” OR “workstation”). We executed separate searches for each combination and used the duplicate detection function in Zotero to remove duplicates. We limited our SLR to publications from year 2010 or later due to the significant technological advances in the past decade [14]. Only peer-reviewed, and, due to language barriers, only publications in English and German were included.

Our systematic search in the selected databases listed in Figure 1 yielded 338 unique publications complying to the inclusion criteria. In order to include relevant publications not matching the keywords, we manually scanned the contents of the AIS senior scholars basket⁴ as well as relevant journals and conferences on the Human-Computer Interaction field selected from the Google Scholar h5-index ranking⁵ with the same inclusion criteria. Thereby, we added 30 additional results, totalling at 368 publications. In the first step, we sorted out any publications that do not contribute a WCA concept, i.e. a CA concept which is either used by a working person (Cat. I) or which is not used by a working person, but does impact the work of another person who is not necessarily involved in the user-CA dialogue (Cat. II). After categorizing the remaining publications into these two categories, we performed a forward and backward search on the Cat. I publications as they are more relevant to our research goal. In total, we found 35 publications with Cat. I WCAs and 46 publications with Cat. II WCAs. A summary of our search and filtering process is provided in Figure 1.

4. Results

In this section, we describe our observations in our result set, then we summarize and classify the WCA concepts. Eventually, we summarize design aspects and other findings from those WCA concepts. Based on the 81 publications in our result set, we identified 29 WCAs

⁴<https://aisnet.org/page/SeniorScholarBasket>

⁵<http://bit.ly/2WW1Vep>

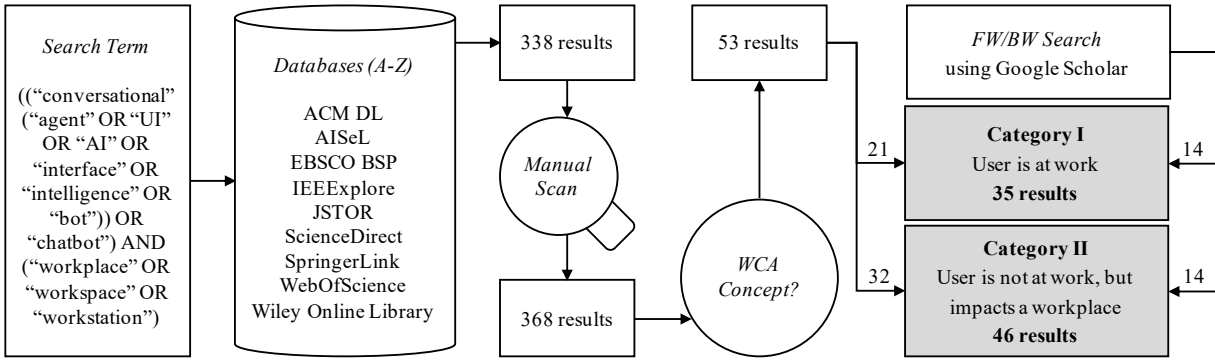


Figure 1. Our Systematic Literature Review Process

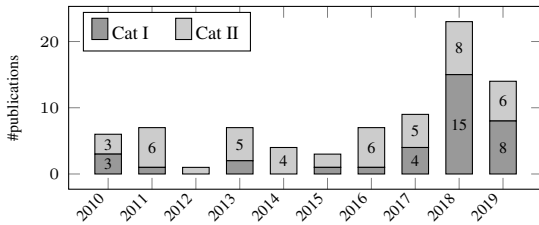


Figure 2. Distribution of Publications over Time

for workers in eight application domains and three main application domains of WCAs for non-workers.

4.1. Descriptive Results

In our final set of publications we observe a massive peak in the number of publications in year 2018 as depicted in Figure 2. This supports our claim that it is only the advent of WCAs, facilitated by recent technological advancements and subsequent possibilities. Although there is a drop in the number of publications in year 2019, it should be noted that this SLR was conducted in April/May 2019⁶, thus with more than half of the year still upcoming. The U.S. and the U.K. lead the number of papers with at least one author affiliated to an institution in those countries with a total of 38 and 12 publications out of all 81 publications, respectively. This is not surprising: Many leading tech companies reside in the U.S. and there is interest in WCAs due to its high potential in commercial value. In addition, the skew towards English-speaking countries can be explained by the research efforts invested into modules like Natural Language Processing, which again, are often driven by large tech enterprises. Nonetheless, the total of 25

⁶Note: During revision of this paper in September 2019, a few additional papers published after April/May 2019 were added through a new forward/backward search.

countries from all over the world indicate the emerging interest in WCAs generally.

4.2. Classification of WCAs

Next to the dimensions used for classification of CAs in general, we realized during this SLR that additional dimensions are needed to classify WCAs properly. In particular, there is the productive-collaborative aspect of WCAs and the workplace it is designed for. Therefore, we use a combination of different dimensions to classify the WCAs in the following:

- **General CA Dimensions** are dimensions typically used for all types of CAs, as listed in Table 1. These include: *Domain Depth* (DD) and *Breadth* (DB), *Session Length* (SL), *Goal Direction* (GD), *Emotionality* (EMO), *Representation* (REP) and *Modalities* (MOD).
- **Collaborative Dimensions** are additional dimensions specific to a human-CA collaborative setup. These include: *Role* (RO - Faciliator, Peer, Expert), *No. of Humans* (NH - Individual, Team, Crowd), *NCA - No. of CAs* (Single, Multiple), as proposed by Bittner et al. [18]
- **Workplace Dimensions** are additional dimensions for the particular operating place of the WCA. These include: *Impact* (IMP - Decision Making, Control, Productivity, Social Interaction, Job Enhancement, Work Environment) and *Type of Worker* (WO - Managers, Professionals, Clericals/Technicians), as proposed by Kraemer and Danziger [21] for information workers. Due to the small amount of relevant WCAs for manual workers, we proposed to add “Manual Worker” as another value in the WO dimension without further differentiation.

4.3. WCAs for Workers

We observed that among the 29 WCAs for workers (WWCAs), i.e. WCAs where the target audience are people at their respective work and workplace, the degree to which the added human characteristics of a CA were made use of varies immensely. However, this is also reasoned by the variety of application domains, of which we identified eight, as each case demands different CA characteristics. Table 2 provides an overview of the WWCAs and their classification.

Working Tool. The most common application domain among our WWCAs is to use the WCA as a tool for specific work purposes. Examples for this are Ava [22] and Iris [23], two WCAs for data scientists to perform statistical analyses. Similarly, MSRBot [24] provides insights into software code repositories by executing analytic searches. Isa [25] automatically detects customer contexts for customer service agents and provide relevant information for the agent to use, therefore being a valuable tool for seasonal workers. For neuroscience labs [26], 3D modelers [27] and bio labs [28], WCAs have been proposed to provide respective just-in-time assistance to tackle work challenges.

Information Retrieval. WCAs are often used as easy-to-use interfaces for search engines as missing information in a search query can be inquired in a natural dialogue to specify the desired information. Therefore, information retrieval WCAs are often proposed in the form of an anthropomorphised information desk agent, e.g. for anti-bullying information [29, 30], HR FAQ [31], construction safety information [32]. However, pragmatic WCAs without anthropomorphism are also proposed, e.g. to access building information [33] or to improve the accessibility of organizational information [34]. A special case is proposed in FarmChat [35] where the information provided by the WCA is respected as expert advice rather than retrieval of existing knowledge.

Routine Assistance. Similar to the working tools, Routine Assistance WCAs assist users in their work to become more productive. However, as the name indicates, their focus is on executing complex, but repeating routines that are rather administrative and/or auxiliary than an actual part of the role. This applies to meeting scheduling [36], administrative tasks accompanying courses [37], plug management in the office [38], personal and group task management [39] or incident reporting [40].

Virtual Colleague. The virtual colleague is an application domain where a strong anthropomorphism is desired as the WCA should represent a human

being. In [41], the (user-programmed) WCA acts as an embodied co-presenter and in [42], the WCA represents a new hire mentor, both providing information and sending reminders and news proactively. A different application of a virtual colleague is to relieve solitude and prevent driver fatigue by conducting conversations with a truck driver during driving [43, 44, 45].

Work Environment. For the particular group of crowdworkers, WCAs have been proposed to be used as a mobile and intuitive interface [46] or, for them to actually work “inside” a CA as their workplace, providing crowd human intelligence to mimic a CA [47, 48]. It can be debatable whether the latter can be classified as a WCA, however, as there are workers involved in this WCA, we decided to sort it into this application domain.

Decision Making. Similar to human capabilities, WCAs can act as a mediator for group decisions (e.g. for group lunches [49]), or multiple WCAs can represent different steps of thought to assist the user in more complex decision making [50, 51].

Reflection and Control. Kocielnik et al. proposed the usage of a WCA to enable users to log a work journal for reflection purposes [52]. While UpTime [53] is a system to help users to cut out distractions, the CA element provides a possibility for the user to reflect on whether they really need to view the blocked page.

Team Creation. Lastly, a WCA can also help creating teams by analyzing member candidates in a psychological manner to identify matching profiles as proposed by Tseng et al. [54].

4.4. WCAs for Non-Workers

WCAs for non-workers are WCAs of which the main target audience are not working people. However, they are designed to be operated at one’s workplace and thus influence the work and workplace of a person different than the user. The most prevalent goals of a WCA are to support or even replace human work. Therefore, we present selected and important application domains in more detail in the following.

In the area of **health care** several applications were proposed, such as a virtual discharge nurse [55, 56], as a counsellor for mental health issues [57, 58] and stress relief [59], as a trustworthy partner to talk about sensitive topics [60], to facilitate scalable depression and suicidal prevention [61, 62], to enable self-reflection and behavior change [63, 64] or to support care and monitoring for elderly people [65, 66]. In all of these cases, the main user is not a working person, but rather a patient. However, successful establishment of either of these systems can greatly impact the work of the medical

Source	App. Domain	DD	DB	SL	GD	EMO	REP	MOD	RO	NH	NCA	IMP	WO
[22]	Working Tool	D	N	MIN	NGO	NEMO	DEMB	T	F	IND	SING	PROD	PRO
[23]	Working Tool	D	N	MIN	NGO	NEMO	DEMB	T	F	IND	SING	PROD	PRO
[24]	Working Tool	D	N	MIN	NGO	NEMO	DEMB	T	F	IND	SING	PROD	PRO
[25]	Working Tool	D	N	MIN	NGO	NEMO	DEMB	T	F	IND	SING	PROD	C/T
[26]	Working Tool	S	N	MIN	GO	NEMO	DEMB	T	F	IND	SING	PROD	PRO
[27]	Working Tool	D	N	-	NGO	NEMO	DEMB	T	F	IND	SING	PROD	PRO
[28]	Working Tool	S	N	-	NGO	NEMO	DEMB	S	F/P	IND	SING	PROD	PRO
[29, 30]	Info. Retrieval	D	N	MIN	GO	NEMO	DE	T, H	F/P	IND	SING	WE	ALL
[31]	Info. Retrieval	S	B	MIN	NGO	NEMO	DEMB	T	F	IND	SING	PROD	INFO
[32]	Info. Retrieval	S	B	MIN	NGO	NEMO	EMB	T, S	F	IND	SING	PROD	ALL
[33]	Info. Retrieval	S	N	MIN	NGO	NEMO	DEMB	T	F	IND	SING	CTRL	ALL
[34]	Info. Retrieval	S	B	MIN	NGO	NEMO	DE	T	F	IND	SING	WE	INFO
[35]	Info. Retrieval	D	B	MIN	GO	NEMO	DE	T, S	E	IND	SING	PROD	PRO
[36]	Routine Assist.	S	N	MIN	GO	NEMO	DE	T	F	TEAM	SING	PROD	INFO
[37]	Routine Assist.												
[38]	Routine Assist.	S	N	MIN	GO	NEMO	DEMB	T	F	IND	SING	CTRL	INFO
[39]	Routine Assist.	S	N	MIN	GO	NEMO	DEMB	T	F	TEAM	SING	PROD	INFO
[40]	Routine Assist.	S	N	MIN	GO	NEMO	DEMB	-	F	IND	SING	PROD	MW
[41]	Virtual Colleague	S	N	-	GO	NEMO	EMB	S	P	IND	SING	PROD	PRO
[42]	Virtual Colleague	N	B	-	GO	-	DEMB	T	P	IND	SING	PROD	INFO
[43, 44]	Virtual Colleague	D	B	MAX	GO	EMO	-	S	P	IND	SING, MULT	WENV	MW
[45]	Virtual Colleague	S	B	MIN	GO	NEMO	DEMB	S	F/P	IND	SING	WENV	MW
[46]	Work Environ.	S	N	-	GO	NEMO	DEMB	T, S	F	IND	SING	PROD, JOB	PRO
[47, 48]	Work Environ.	S	N	-	GO	NEMO	DEMB	T, S	F	IND	SING	PROD, WENV	INFO
[49]	Decision Support	S	N	MIN	GO	NEMO	DEMB	T	F	TEAM	SING	DECM	INFO
[50, 51]	Decision Support	D	N	-	GO	NEMO	DEMB	-	E	IND	MULT	DECM	MAN, PRO
[52]	Reflection	S	N	MAX	GO	NEMO	DEMB	T, S	F	IND	SING	WENV	ALL
[53]	Reflection	S	N	MIN	GO	NEMO	DEMB	T	F	IND	SING	CTRL	INFO
[54]	Team Creation	S	N	MIN	GO	NEMO	DEMB	T	P	IND	SING	PROD	INFO

Legend: **DD** - Domain Depth: D - Deep, S - Shallow • **DB** - Domain Breadth: N - Narrow, B - Broad • **SL** - Session Length: MIN - Minimal, MAX - Maximal • **GD** - Goal Direction: GO - Goal-Oriented, NGO - Non-Goal-Oriented • **EMO** - Emotionality: EMO - Emotional, NEMO - Non-Emotional • **REP** - Representation: EMB - Embodied, DEMB - Disembodied • **MOD** - Modalities: T - Text, S - Speech, H - Haptic • **RO** - Role: F - Facilitator, P - Peer, E - Expert • **NH** - No. of Humans: IND - Individual, TEAM - Team, CROWD - Crowd • **NCA** - No. of CAs: SING - Single, MULT - Multiple • **IMP** - Impact: DECM - Decision Making, CTRL - Control, PROD - Productivity, SI - Social Interaction, JOB - Job Enhancement, WENV - Work Environment • **WO** - Type of Worker: MAN - Managers, PRO - Professionals, C/T - Clericals/Technicians, MW - Manual Worker, ALL - All

Table 2. Classification of WCAs for workers. Dimensions are abbreviated as introduced in Section 4.2.

staff. A similar constellation of user and impacted persons can be observed in the application domain of **teaching, coaching and tutoring**. The usage of CAs as a virtual teacher [67], to support peer learning and knowledge building [68] and as a learning partner [69] were proposed in the publications in our result set.

WCAs for non-workers that impact a workplace are also used for **automation** purposes. This includes the virtualization of service roles, such as pre- and post-sales customer service [70, 71, 72, 73], in information providing services [74], airport security [75] and tech support desks [76]. While the earlier application domains mainly use WCAs as a supportive tool to relieve the workers impacted, automation may pose a threat to the respective jobs as they may make the human-added value negligible.

4.5. Design Aspects of WWCAAs

Several of the above mentioned WWCAAs have been evaluated in studies to inform the design of such CAs. Therefore, we summarize the findings from the respective studies to extract aspects that require special attention when designing a WWCA. These aspects, however, need to be tested in further evaluations in order to formulate generalizable design principles. Also, we do not claim these aspects to be WWCA-specific as most of these apply to any CAs, or system at the workplace.

Design for Diversity. Diversity is present in different forms at the workplace, including differently enabled people. With the flexibility of modalities for WWCAAs, it can be advantageous to provide multiple, concurrent modalities (e.g. speech, text), different representations of the same information (e.g. visual, textual) [35] or different levels of detail [24]. Clear instructions and clear turn-taking mechanisms should be implemented as well as resilient repair strategies in case of a breakdown to fool-proof the CA for non-tech-savvy users [29]. The workplace needs to be taken into consideration, workers in noisy environments (e.g. lab) can hardly use audio-based CAs [28], while the farmers using FarmChat [35] had a hard time seeing displayed information in the direct sunlight.

Efficient Modalities. Time at the workplace is costly, therefore, an efficient modality should be selected for the WWCA. Text has proven to be faster and clearer, while audio is better suitable for illiterate users and provides a more natural and anthropomorphized way of communication with the CA [35]. In the workplace context, some tasks are perceived differently depending on the input medium, e.g. journaling feels more like a formal report when actually spoken [52]. It should be taken into consideration that speech can be

overheard by surrounding people which, in most cases, is not a desired effect due to privacy concerns [52] or competition among peers [35]. As of the WWCAAs in our SLR, many of the CAs make use of already existing communication means in the digital workplace, e.g. Slack, Skype, email or other Instant Messengers [39, 52, 31, 53, 36, 77]. This acts as a preliminary assurance that the user is already familiar with the basic functions of the application.

Privacy and Data Protection. With the workplace being a sensitive environment, it is important to ensure conversations with the WWCA to be as private and anonymous as possible. This applies to handling with sensitive topics like bullying and harassment [29] as well as any personal information like individual availability and appointments [36], personal thoughts [52] or logs of individual behavior at work [53]. It can also help to be transparent to the user about the personal data stored [53].

Reliability and Resilience. At the workplace, system performance is a strong predictor for user satisfaction, even more than the friendliness of the CA [31]. The user has to trust the CA as stakes are usually high at the workplace [35, 41]. In case of a breakdown, the CA should fail gracefully [39] rather than doing “the next best thing” to maintain the user’s trust and the façade of a properly running system.

Proactivity and Risk of Interruption. WWCAAs are often designed to be capable of being proactive [42]. Therefore, the value of the interruption and the perceived severity of interruption needs to be precisely balanced [31, 53]. Using the user’s current context, e.g. through calendars or using ubiquitous devices [78], the cost of interruption can be decreased by choosing low-cost moments [31, 39].

Mental Model. The mental model that the user creates in his mind influences the degree of the user’s acceptance. Tseng et al. [53] report that some participants refused to negotiate with the CA because they perceived it as a machine rather than a conscious being worth bargaining with.

Implications on the Workplace. Highly anthropomatic, assistive WWCAAs may appear to be human to strangers. This may elevate the user’s apparent hierarchical position, since having an assistant is often an indicator for superiority [36], which is an effect that is sometimes unwanted (e.g. when communicating to the manager). WWCAAs also bear the risk of eliminating human interactions that are vital in team work [36] or over-controlling workers to a level where they lose their own sense of control [53].

5. Discussion

We structure our discussion as follows: First, we describe the limitations to this study, then, we point out observations we made during the analysis of the publications. Lastly, we discuss the implication for further research and propose research questions as starting points.

5.1. Limitations

There are several limitations to this work: Due to our selection of data sources, we do not claim that our SLR is exhaustive. In particular, this topic has proven to be a very recent item of study and most probably still part of ongoing, unpublished research. The literature included in this work are primarily retrieved in April/May 2019 with minor additions in September 2019. Also, we only included literature from 2010 or newer due to the increased interest in this topic in the recent years. This inclusion criteria may have created a recency bias in our results. The design aspects we extracted originated from publications with empirical evaluations of their concepts with no further classification of their quality. Thus, the aspects only rely on the quality of its respective source and were not re-evaluated in the scope of this work. As mentioned in Section 4.1, the majority of publications had affiliations to an institution in the U.S. and the U.K. Therefore, our results may only reflect concepts and design aspects conceivable and important to the Western culture and the Western way of working. Lastly, we only included WWCA concepts where the CA is the main contribution, i.e. concepts including a physical embodiment (robot) were excluded.

5.2. Observations

Our main observation for WWCA are apparent in Table 2: In the workplace context, CAs to this day are primarily used for purposes that do not require many human characteristics besides of a name, i.e. almost none of the WWCA are emotional or have an anthropomorphised embodiment. This may be reasoned by the primary impact of improvement in productivity which can be optimally achieved with pragmatic systems with little conversational overhead. Same reason could explain the fact that text input is the most prevalent modality for input and output. Text can be read in a faster, individual pace or be only scanned while speech becomes inaudible with increasing speed. Furthermore, most of the WWCA concepts we found are designed to be used in an office, thus targets at information workers. In an office, speech input and output may not be suitable as explained in Section 4.5.

5.3. Implications and Further Research

The majority of research on this topic originate from English-speaking, “Western” countries. This raises the question whether there are culture-bound differences, e.g. in preferred modality, WWCA personality or generally the acceptance of a CA at the workplace. We expect that with the on-going advancements in NLU for other languages, the usage of a WWCA becomes more conceivable in the near future for other cultures and would propose the investigations of parallels and differences in design of such in comparison to the previously presented.

We have extracted several design aspects to be taken into consideration from our result set. However, concrete design principles need to be developed, instantiated and validated in more studies, including different industries, application domains, countries, roles and (company) cultures. We expect design principles for WWCA to be culture-bound and differ depending on application domain and workplace.

As mentioned in our observations, almost all of the WWCA retrieved in our SLR target information workers. Certainly, it is more conceivable to integrate a CA into the workplace due to the existing technology at an office workplace, however, as proven by FarmChat [35], WWCA can also be of high value to low-tech and manual workers. Therefore, we encourage future research to explore the transferability of existing application domains for manual workers, or define new applications domains specific to manual workers.

6. Conclusion

Our SLR revealed that there are two substantially different types of CAs at the workplace: Namely, those facing the worker and those facing a non-working person, yet having a great impact on the workplace. We have identified 29 CAs for the workplace and for working users (WWCA) which contribute to eight different application domains, ranging from a working tool with little anthropomorphism to a human-like virtual colleague. From these WWCA, we extracted seven aspects that need to be particularly considered when designing a WWCA, however, it is yet to be investigated in further research as the number of studies performed on the WWCA is still relatively small. Nonetheless, our SLR supported the claim that WCA are emerging quickly [5] and should be an item of interest in further CA research.

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